

LOWER COOK INLET PINK SALMON FORECAST FOR 1992

By

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ABSTRACT

The total number of pink salmon *Oncorhynchus gorbuscha* returning to 11 Lower Cook Inlet streams or drainage systems in 1992 was forecasted to be 734,503. Associated harvest was projected to be 427,298 with an potential escapement shortfall of 65,295 in Windy, Rocky, and Resurrection Bays, and Ursus and Rocky Coves. Lower and upper 80% confidence limits around the total run forecast were 269,292 and 2,003,389, respectively with corresponding harvest projected to range between 88,385 and 2,436,694. Potential escapement shortfall may be as high as 163,863 in nine harvest areas if runs to all harvest areas were at the lower forecast bound.

Log-log regression models of returning adults on spawning escapements were used to produce forecasts for each stream or drainage system. Cross-validation of the individual runs to the 11 harvest areas as well as the total run to Lower Cook Inlet were used to reconstruct historical forecasts errors. The reconstructed forecast errors were used to calculate SD and 80% confidence limits.

Wide confidence intervals about the run forecast indicated the high degree of uncertainty involved in predicting the actual run. The fraction of historical runs and of reconstructed forecasts that were both comparable to the 1992 forecast and correct were also presented for each harvest areas.

KEY WORDS: *Oncorhynchus gorbuscha*, pink salmon, forecast, Lower Cook Inlet.

INTRODUCTION

This was only the third year that a forecast of pink salmon *Oncorhynchus gorbuscha* run size was made for Lower Cook Inlet (Figure 1). Individual forecasts of 1992 runs were made for 11 harvest areas for which historical records of commercial catches and spawning escapements were available. Pink salmon fisheries within these 11 areas have been managed to obtain spawning escapement goals in associated streams and drainages. The objective of this report was to document methods used to produce forecasts of wild pink salmon runs to Lower Cook Inlet in 1992. Forecasts of hatchery pink salmon runs (e.g. Tutka Lagoon), prepared by staff within the Division of Fisheries Rehabilitation, Enhancement and Development, will be included in the annual statewide salmon forecast report (Geiger and Savikko 1992).

METHODS

Forecasts of wild pink salmon runs were prepared individually for 11 harvest areas in the Lower Cook Inlet management area. The forecast for each harvest area was the number of pink salmon expected to return in 1992 as a result of spawning escapements obtained in 1990. Harvest projections were obtained by subtracting the area specific escapement goal from the forecasted run. If the forecasted run was less than the escapement goal, the projected harvest was zero. Cross-validation was used to reconstruct historical forecast errors by harvest areas. These were used to derive a SD and an 80% confidence limit around the individual harvest area forecasts. Projected harvest associated with the forecast bounds were calculated with the corresponding escapement ranges. Escapement ranges, however, were not available for Ursus and Rocky Cove, Resurrection Bay, and Rocky Bay, so spawning escapement goals for these systems were used instead to calculate the projected harvest associated with the upper and lower forecast bounds.

The total run forecast to Lower Cook Inlet, defined in this report as the aggregate of the 11 harvest areas only, was the sum of the individual harvest area forecast. The upper and lower bounds around the total run forecast, however, were derived from a cross-validation of the total runs. The composite escapement goal and projected harvest were the sum of the individual escapement goals and harvest areas. The total projected harvest can not be calculated from the difference between the total forecasted run and total escapement goal or escapement range because of potential escapement shortfalls in specific harvest areas.

Run Forecast Model

Pink salmon runs to individual harvest areas were forecasted from a log-log regressions of total return on spawning escapement (Yuen 1989):

$$F_{h,y} = e^{a+b \ln E_{h,y-2}}, \quad (1)$$

where $F_{h,y}$ = forecast total return (i.e. catch_y + escapement_y) in harvest area h and year y ; $E_{h,y-2}$ = parental spawning escapement; a = regression intercept; b = regression coefficient (slope); e = 2.1783; and the function \ln was the natural logarithm. An F-Test of analysis of variance results was used to test the null hypothesis that the regression coefficient was equal to zero. The null hypothesis was not rejected unless $P < 0.25$.

Data Base

Total return and spawning escapement data for the 1960 to 1990 brood years were obtained from annual management reports (e.g. Schroeder and Morrison 1990). While long term records of pink salmon commercial harvests were available for at least 15 areas in Lower Cook Inlet, corresponding estimates of spawning escapement were available for only 12. Forecasts, however, were prepared for only 11 harvest areas, representing 23 spawning systems (Table 1). While data were available to prepare a forecast for Dogfish Lagoon, no forecast was made since this area did not have a pink salmon spawning escapement goal. Data for some brood years were omitted from the data set (Appendices A-L) because cross-validated forecasts (explained in the next section) for those brood years had errors > 999%.

Confidence Interval by Harvest Area

In a cross-validation by harvest area, (a) spawner and return data were removed from the data file one brood year at a time; (b) a log-log regression model was built using the remaining data; (c) the run was forecast for the excluded brood year; and (d) historical forecast errors or residuals r were reconstructed as:

$$r_{h,y} = \ln(\text{cross validated } F_{h,y}) - \ln(\text{catch}_{h,y} + \text{escapement}_{h,y}). \quad (2)$$

The excluded brood year was returned to the data set and this process was repeated for all brood years. The sum of the square of the reconstructed historical forecast errors was then used to estimate the cross-validation SD :

$$SD_h = \sqrt{\frac{\sum_{i=1}^n r_{h,i}^2}{n-1}}, \quad (3)$$

where n = number of brood years in data set (after exclusion of the year being forecast and those with 999% forecast errors). The confidence interval was

$$F_{h,y} - t_{0.1} SD_h \leq F_{h,y} \leq F_{h,y} + t_{0.1} SD_h, \quad (4)$$

where $t_{0.1}$ is the $(1-0.1/2)$ quantile of the Student's t distribution on $n-1$ degrees of freedom;

Confidence Interval for Lower Cook Inlet

The Lower Cook Inlet forecast, i.e. aggregate of 11 harvest areas, was

$$F_{LCI,y} = \sum_{h=1}^H F_{h,y}. \quad (5)$$

Its confidence limit was based on the forecast errors from a simultaneous cross-validation of all harvest areas where

$$r_{LCI,y} = \ln\left(\sum_{h=1}^H \text{cross validated } F_{h,y}\right) - \ln\left(\sum_{h=1}^H \text{catch}_{h,y} + \text{escapement}_{h,y}\right), \quad (6)$$

and

H varied among years because brood year data from some harvest areas were excluded from the data set (Table 2).

$$SE_{LCI} = \sqrt{\frac{\sum_{i=1}^n r_{LCI,i}^2}{n-1}}. \quad (7)$$

Historical Perspective

The fraction of historical forecast ranges that encompassed the observed runs were estimated by performing a second cross-validation within the cross-validation described above. The second cross-validation is required to reconstruct the confidence bounds around the historical forecast. In this procedure, two brood years were simultaneously excluded from the data set, the year being reconstructed and one year from the remaining brood year in the data set. The reconstructed historical confidence intervals were then used to estimate the fraction of runs that were below, within, or above its 80% confidence interval.

RESULTS

Eight of the 11 harvest areas for which forecasts were made had brood year data omitted from the final spawner-return data set because of 999% cross-validated forecast errors (Table 2). All log-log models, except the one used for Humpy Creek, had slopes significantly different from zero ($P < 0.25$; Table 2). The Humpy Creek model had a slope significantly different from zero at ($P < 0.75$).

The sum of the forecasted runs to 11 Lower Cook Inlet harvest areas for 1992 was 734,503 pink salmon. Total projected catch was 427,298 pink salmon. No harvests were projected for Windy, Rocky, and Resurrection Bays and Ursus-Rocky Coves, since forecasted runs were less than spawning escapement goals for these areas (Table 3).

Forecast ranges for each harvest area are presented in Table 3. The sum of the lower or upper bounds derived from a cross-validation of the individual harvest areas will not match that for the Lower Cook Inlet total. The latter, a lower and upper bound of 269,292 and 2,003,389, is presented in Table 3.

Historically, the performance of the 11 forecast have been independent, where most runs were within the forecast range, a few above, and a few below. Thus, we do not expect, for example, all 11 runs to be below the forecast range. However, if all 11 runs were to be at the lower forecast range, the projected catch would be 88,385. Similar projection at the upper bound was 2,436,694.

DISCUSSION

Pink salmon spawning escapements goals in 1990, the brood year for 1992 runs, were not met in all harvest areas in Lower Cook Inlet (Table 3). Spawning escapements to Bruin Bay, Humpy Creek, Nuka Bay, Port Dick, Port Graham, and Seldovia Bay were within desired spawning ranges in 1990. Runs to these areas in 1992 are expected to exceed spawning requirements and to have surplus for harvest. Spawning escapements to Resurrection Bay, Rocky Bay, and Windy Bay, Ursus and Rocky Coves were below desired spawning ranges in 1990. Runs to these areas in 1992 are expected to be below escapement requirements and to have no surplus for harvest. Spawning escapements to Port Chatham exceeded desired spawning ranges in 1990. Runs to this area in 1992 are expected to exceed spawning requirements and to have a harvestable surplus.

Wide 80% confidence intervals show the large degree of uncertainty associated with the 1992 pink salmon forecast (Table 3). The 1992 forecast and confidence intervals for the individual harvest areas were based on the same techniques used to forecast runs in 1991. The 1992 confidence interval for the Lower Cook Inlet total, however, was based on cross-validated total run errors. The 1991 forecast range were simply the sum of the individual lower and upper bounds. The 1991 method would have produced a wider range, 199,522 - 2,906,694.

To put the 1992 forecast in perspective, the fraction of the historical runs that were comparable to that forecast for 1992, i.e. within the 1992 forecast range, is presented in Table 4. For example, 23 of the past 29 runs in Humpy Creek were similar in size to that forecasted for 1992 (0.793 from Table 4 multiplied by 29 years from Appendix A). The fraction of historical forecast that were comparable to that presented for 1992 is also presented in Table 4. For example, 23 of the reconstructed historical forecast were similar to the 1992 forecast. Of the 23 years, 22 of the observed runs were within the reconstructed historical forecast ranges (0.957 X 23).

Although nine of the individual 1991 harvest area forecasts were within forecast 80% confidence intervals, the total point forecast was 74% greater than the actual pink salmon run (Table 5). Similar overforecast errors were observed for hatchery stocks (Geiger and Savikko 1992). Only one variable, number of spawners, has been used to forecast pink salmon runs. Only three of the 11 harvest areas (Windy Bay, Rocky Bay, Bruin Bay) had more than 50% of the variability in past run sizes explained by spawning escapement. Obviously, factors other than number of spawners greatly influence pink salmon production. While causes of lower than expected pink salmon production from 1991 brood year

spawning escapements have not be identified, it is possible that production from 1990 spawning escapements could also be depressed.

The forecast ranges in this report supersedes those in the statewide forecast (Geiger and Savikko 1992) which were calculated from a regression SE. Additionally, the escapement and forecast for Ursus and Rocky Coves in the statewide forecast should have been 3,880 instead of 37,600 and 13,304 instead of 38,709, respectively.

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Table 1. Pink salmon harvest and spawning areas for which run forecasts were made, Lower Cook Inlet, 1992.

Harvest Area	Corresponding Spawning Area(s)
Humpy Creek	Humpy Creek
Seldovia Bay	Seldovia River
Port Graham Bay	Port Graham River
Port Chatham	Port Chatham Creeks
Windy Bay	Windy Left and Windy Right Creeks
Rocky Bay	Rocky River
Port Dick Bay	Port Dick and Island Creeks
Nuka Bay	South Nuka, Desire Lake Creek, James Lagoon
Resurrection Bay	Bear, Salmon, Mayor, Clear, Thumb, Humpy and Tonsina Creeks
Bruin Bay	Bruin Bay River and Amakdedori Creek
Rocky and Ursus Coves	Sunday and Brown's Peak Creek

Table 2. Linear regression statistics for models used to forecast runs of pink salmon to Lower Cook Inlet harvest areas in 1992. Statistics shown for each model were the Y-intercept (a), regression coefficient (b), standard error of prediction (SE), coefficient of determination (r^2), F-value (F), degrees of freedom (d.f.), and years which were omitted from analyses.

Harvest Area	a	b	SE	r^2	F	d.f.	Brood Years Omitted
Humpy Creek	10.15580	0.11342	0.930	0.011	0.29	1,27	67
Seldovia Bay	5.39966	0.52964	0.965	0.118	3.73	1,28	none
Port Graham	5.51336	0.48437	0.865	0.252	9.45	1,28	none
Port Chatham	7.60931	0.26929	0.950	0.091	1.71	1,17	61,63,65,67,68,69,70,72,74
Windy Bay	0.55223	1.00280	1.026	0.688	59.59	1,27	70
Rocky Bay	2.25585	0.77218	1.157	0.544	33.46	1,28	none
Port Dick Bay	4.20894	0.76488	0.829	0.482	22.31	1,24	70,72,85,86
Nuka Bay	8.63612	0.24318	1.025	0.084	1.83	1,20	61,63,65,67,70,72,74,86
Resurrection Bay	4.12068	0.66132	1.822	0.288	5.67	1,14	61,63,64,65,66,67,69,70,71,73,75,77,79,86
Bruin Bay	5.04556	0.61293	1.264	0.523	17.53	1,16	61,62,63,64,65,66,68,70,71,72,73,81,86
Rocky and Ursus Cove	5.60986	0.47025	1.152	0.319	10.77	1,23	61,67,68,72,88

Table 3. Forecasted pink salmon runs, projected harvests, and potential spawning escapement shortfalls for Lower Cook Inlet, 1992.

Location	1990 Escapement	Forecast			Forecast Range						Potential Escapement Goal Shortfall		
		Run ^a	Escapement ^b	Harvest ^c	Lower Bound			Upper Bound			Forecast	Lower	Upper
					Run ^a	Escapement ^b	Harvest ^c	Run ^a	Escapement ^b	Harvest ^c			
Humpty Creek	27,000	81,885	37,500	44,385	22,999	25,000	0	291,543	50,000	241,543	0	2,001	0
Seldovia Bay	27,782	49,960	30,000	19,960	13,501	25,000	0	184,879	35,000	149,879	0	11,499	0
Port Graham	20,053	30,080	30,000	80	9,350	20,000	0	96,773	40,000	56,773	0	10,650	0
Port Chatham	27,822	31,732	12,500	19,232	8,783	10,000	0	114,654	15,000	99,654	0	1,217	0
Windy Bay	14,618	26,085	50,000	0	6,381	40,000	0	106,622	60,000	46,622	23,915	33,619	0
Rocky Bay	18,250	18,629	50,000	0	3,908	50,000	0	88,805	50,000	38,805	31,371	46,092	0
Port Dick	66,706	329,490	60,000	269,490	104,572	20,000	84,572	1,038,165	100,000	938,165	0	0	0
Nuka Bay	18,486	61,407	15,000	46,407	13,813	10,000	3,813	273,001	20,000	253,001	0	0	0
Resurrection Bay	9,706	26,687	30,000	0	2,870	30,000	0	248,137	30,000	218,137	3,313	27,130	0
Bruin Bay	19,050	65,244	37,500	27,744	10,756	25,000	0	395,743	50,000	345,743	0	14,244	0
Ursus & Rocky Cove	3,380	13,304	20,000	0	2,589	20,000	0	68,372	20,000	48,372	6,696	17,411	0
Lower Cook Inlet ^d	252,853	734,503	372,500	427,298	269,292	275,000	88,385	2,003,389	470,000	2,436,694	65,295	163,863	0

^a Estimated lower and upper bounds for runs based on 80% confidence interval of forecast.

^b Estimated lower and upper bounds for escapements based on ranges currently used for management.

^c Estimated lower and upper bounds for harvests are differences between runs and escapements.

^d Estimated Lower Cook Inlet lower and upper bounds, were derived independently and will not equal the sum of that derived for the harvest areas.

Table 4. The 1992 forecast in historical perspective.

Harvest Area	1992 forecast lower bound	1992 forecast upper bound	Fraction of historical runs that were similar in size to 1992 forecast ^a	Fraction of historical forecast similar in size to 1992 forecast that were correct ^b	Number of years in sample
Humpy Creek	22,999	291,543	0.793	0.957	23
Seldovia Bay	13,501	184,879	0.833	0.960	25
Port Graham	9,350	96,773	0.733	0.955	22
Port Chatham	8,783	114,654	0.842	0.938	16
Windy Bay	6,382	106,622	0.690	0.850	20
Rocky Bay	3,908	88,805	0.667	0.950	20
Port Dick	104,573	1,038,165	0.615	0.875	16
Nuka Bay	13,813	273,001	0.864	0.947	19
Resurrection Bay	2,870	248,137	0.938	1.000	15
Bruin Bay	10,756	395,743	0.722	0.923	13
Ursus and Rocky Coves	2,589	68,372	0.760	0.842	19

^a Within 1992 forecast bounds.

^b Within reconstructed 80% confidence interval.

Table 5. Forecasted and actual runs of pink salmon to Lower Cook Inlet, 1991.

Harvest Area	Lower 80% Confidence Interval	Forecasted Run	Upper 80% Confidence Interval	Actual Run	Percent Error ^a
Humpy Creek	33,997	108,038	343,325	17,406	521 ^b
Seldovia Bay	13,760	49,478	177,915	30,215	64
Port Graham	9,289	29,400	93,053	28,966	1
Dogfish Bay	185	1,110	6,671	9,322	-88 ^c
Port Chatham	9,412	33,191	117,047	31,239	6
Windy Bay	13,819	54,785	217,199	104,410	-48
Rocky Bay	3,772	13,231	46,410	26,100	-49
Port Dick	100,179	309,672	957,257	359,625	-14
Nuka Bay	21,584	90,358	378,265	38,970	132
Resurrection Bay	8,296	33,895	138,484	339	9898 ^b
Bruin Bay	93,950	514,735	2,820,131	101,688	406
Ursus and Rocky Cove	28,669	127,799	569,691	37,600	240
Total	336,911	1,365,689	5,865,447	785,880	0.74

^a Percent error is (Forecasted Run - Actual Run) / Actual Run.

^b Actual run size below lower bound of 80% confidence interval.

^c Actual run size above upper bound of 80% confidence interval.

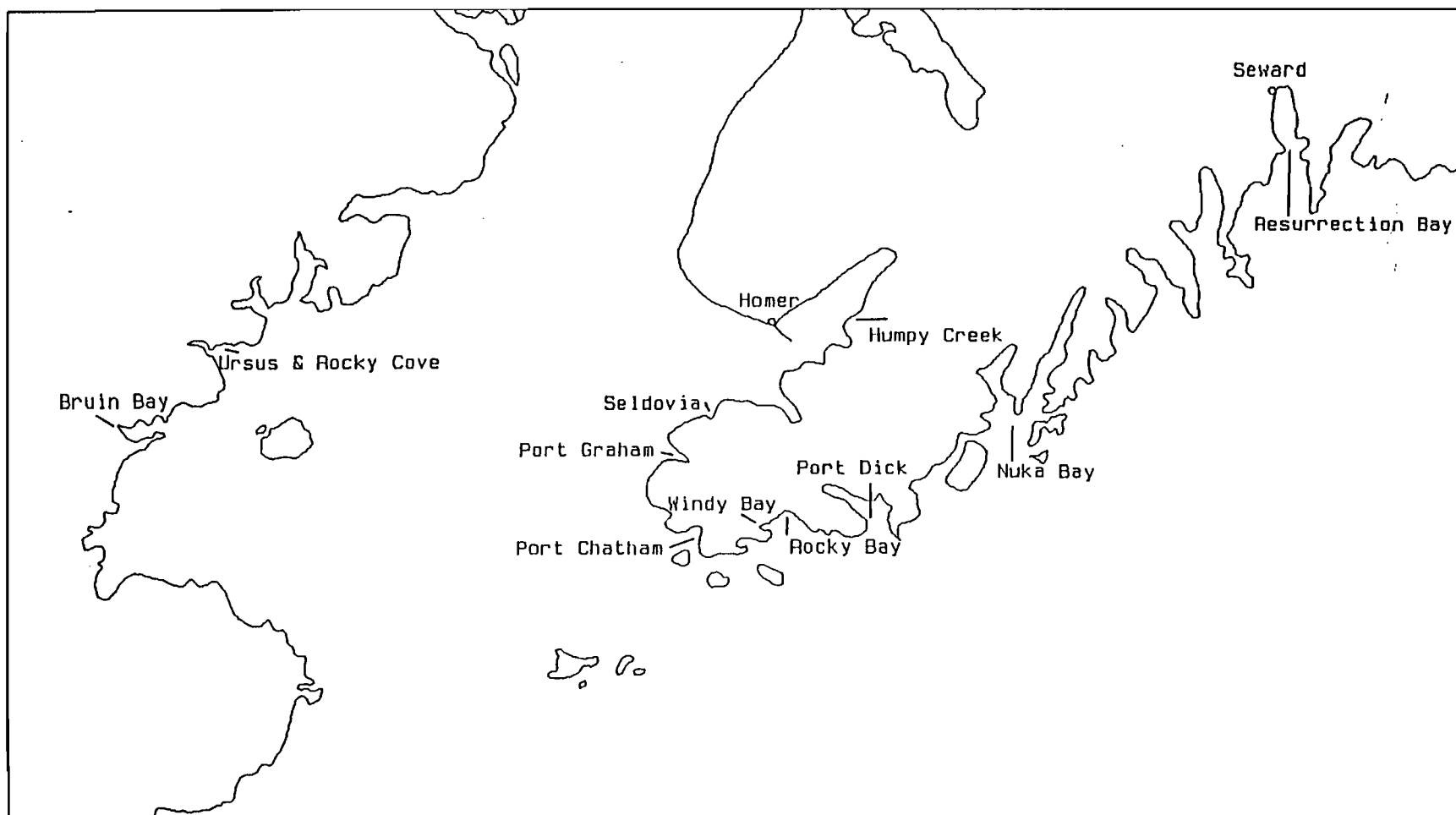


Figure 1. Pink salmon streams in Lower Cook Inlet with formal forecast.

APPENDIX

Appendix A. Spawning escapement and total return data used to forecast 1992 pink salmon run to Humpy Creek, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	10,000	164,800
1961	22,600	92,100
1962	56,000	100,900
1963	34,700	41,800
1964	18,500	70,700
1965	28,000	65,400
1966	30,000	68,600
1968	24,700	169,300
1969	5,400	56,400
1970	55,200	15,900
1971	45,000	81,200
1972	13,800	52,800
1973	36,900	403,300
1974	17,400	100,300
1975	64,000	128,700
1976	27,200	90,100
1977	86,000	504,000
1978	46,100	117,700
1979	200,000	365,900
1980	64,400	37,900
1981	115,000	131,700
1982	31,900	137,700
1983	104,800	128,400
1984	84,200	166,400
1985	117,000	28,600
1986	49,700	21,400
1987	26,600	184,400
1988	21,400	27,000
1989	93,000	17,406
1990	27,000	

Appendix B. Spawning escapement and total return data used to forecast 1992 pink salmon run to Seldovia, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	25,000	192,800
1961	25,000	14,600
1962	50,000	97,400
1963	13,000	49,200
1964	60,000	130,100
1965	30,000	66,700
1966	86,000	76,800
1967	55,000	88,800
1968	53,200	52,000
1969	60,000	58,400
1970	23,000	6,000
1971	31,100	33,900
1972	5,800	17,200
1973	14,500	465,800
1974	13,700	28,600
1975	36,200	83,300
1976	25,600	60,400
1977	35,700	184,500
1978	24,600	147,200
1979	43,700	189,100
1980	65,500	108,700
1981	62,700	71,200
1982	38,400	16,400
1983	27,900	26,600
1984	14,200	31,000
1985	22,800	8,800
1986	28,200	22,400
1987	7,600	27,300
1988	16,900	31,292
1989	26,200	26,365
1990	27,782	

Appendix C. Spawning escapement and total return data used to forecast 1992 pink salmon run to Port Graham, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	15,000	68,100
1961	5,000	4,700
1962	50,000	54,400
1963	2,000	13,900
1964	16,000	29,100
1965	1,500	7,100
1966	24,000	47,400
1967	2,000	6,000
1968	24,400	36,200
1969	4,000	14,200
1970	16,600	3,500
1971	13,200	20,900
1972	2,400	7,300
1973	7,000	45,600
1974	2,800	10,400
1975	27,300	65,400
1976	6,500	10,700
1977	20,600	157,400
1978	6,700	70,700
1979	32,700	64,300
1980	40,200	64,300
1981	18,400	8,700
1982	28,900	18,900
1983	4,600	38,800
1984	10,900	26,300
1985	26,300	6,100
1986	17,500	18,600
1987	3,800	19,100
1988	7,900	20,053
1989	19,100	28,966
1990	20,053	

Appendix D. Spawning escapement and total return data used to forecast 1992 pink salmon run to Port Chatham, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	4,000	109,200
1962	7,000	67,100
1966	10,000	10,000
1971	15,500	25,600
1973	5,000	23,700
1975	7,700	15,600
1977	14,200	195,200
1978	300	9,500
1979	20,800	17,000
1980	7,700	14,600
1981	11,200	6,800
1982	2,000	7,800
1983	3,500	15,900
1984	7,800	11,500
1985	8,900	10,200
1986	11,500	21,000
1987	10,200	41,400
1988	21,000	49,925
1989	31,700	31,239
1990	27,822	

Appendix E. Spawning escapement and total return data used to forecast 1992 pink salmon run to Windy Bay, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	16,000	110,500
1961	15,000	9,400
1962	25,000	82,500
1963	9,400	17,400
1964	13,900	34,100
1965	12,000	12,000
1966	14,000	13,100
1967	12,000	26,200
1968	9,700	15,900
1969	26,200	105,700
1971	48,400	86,000
1972	500	200
1973	17,500	46,500
1974	200	400
1975	28,400	231,600
1976	400	1,400
1977	58,400	637,900
1978	1,400	14,200
1979	85,200	38,900
1980	14,200	9,100
1981	36,000	16,200
1982	9,100	5,900
1983	16,200	19,100
1984	5,900	4,700
1985	14,300	7,600
1986	4,700	4,700
1987	7,600	31,800
1988	4,700	14,618
1989	31,800	104,410
1990	14,618	

Appendix F. Spawning escapement and total return data used to forecast 1992 pink salmon run to Rocky Bay, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	130,000	425,900
1961	2,000	13,400
1962	200,000	133,200
1963	12,000	400
1964	80,000	44,000
1965	300	1,000
1966	44,000	53,900
1967	1,000	1,000
1968	43,100	68,800
1969	1,000	1,700
1970	32,000	8,200
1971	1,600	2,200
1972	8,200	1,500
1973	2,000	4,400
1974	1,500	2,700
1975	4,400	48,300
1976	2,700	8,200
1977	36,700	207,200
1978	8,200	7,800
1979	85,000	41,500
1980	6,400	6,600
1981	25,000	17,900
1982	6,600	9,000
1983	16,600	12,100
1984	9,000	12,000
1985	12,100	4,500
1986	12,000	5,400
1987	4,500	10,300
1988	5,400	18,250
1989	10,300	26,100
1990	18,250	

Appendix G. Spawning escapement and total return data used to forecast 1992 pink salmon run to Port Dick Bay, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	58,200	1,173,300
1961	16,000	80,500
1962	55,000	587,800
1963	61,500	65,800
1964	61,500	338,800
1965	50,500	280,400
1966	42,000	88,300
1967	20,500	63,600
1968	33,300	376,500
1969	12,100	192,500
1971	97,900	123,500
1973	26,900	153,200
1974	2,000	12,700
1975	62,900	991,600
1976	12,700	108,900
1977	109,900	1,081,400
1978	45,300	191,600
1979	116,600	1,271,900
1980	58,300	78,900
1981	131,000	219,400
1982	34,900	164,200
1983	79,400	548,800
1984	79,600	362,200
1987	4,600	62,100
1988	19,200	235,762
1989	62,100	359,625
1990	66,706	

Appendix H. Spawning escapement and total return data used to forecast 1992 pink salmon run to Nuka Bay, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	20,000	169,800
1962	40,000	35,100
1964	11,300	10,000
1966	10,000	100,200
1968	10,000	59,400
1969	3,000	163,700
1971	44,000	27,100
1973	19,000	63,800
1975	28,400	69,100
1976	600	7,300
1977	12,800	139,700
1978	1,000	33,700
1979	18,000	430,100
1980	20,900	27,100
1981	35,000	90,800
1982	18,400	32,000
1983	35,800	225,900
1984	27,600	143,400
1985	75,100	35,800
1987	14,900	102,200
1988	5,400	18,647
1989	59,200	34,970
1990	18,486	

Appendix I. Spawning escapement and total return data used to forecast 1992 pink salmon run to Resurrection Bay, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	1,400	3,400
1962	3,300	8,200
1968	7,600	40,200
1972	1,100	8,500
1974	8,500	76,000
1976	40,600	55,800
1978	26,100	196,500
1980	40,700	189,300
1981	2,700	40,700
1982	51,900	155,200
1983	13,600	149,300
1984	32,900	77,200
1985	74,700	23,400
1987	11,600	9,000
1988	1,100	9,706
1989	9,000	339
1990	9,706	

Appendix J. Spawning escapement and total return data used to forecast 1992 pink salmon run to Bruin Bay, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	78,000	380,000
1967	500	5,000
1969	5,000	11,700
1973	2,000	20,000
1974	600	13,500
1975	20,000	66,200
1976	13,500	33,900
1977	60,000	246,300
1978	33,900	504,400
1979	206,000	148,400
1980	403,800	94,600
1982	81,300	235,200
1983	4,200	4,500
1984	110,000	1,555,700
1985	4,500	25,600
1987	24,400	554,800
1988	30,000	19,847
1989	352,000	102,388
1990	19,050	

Appendix K. Spawning escapement and total return data used to forecast 1992 pink salmon run to Ursus and Rocky Cove, Lower Cook Inlet.

Brood Year	Spawning Escapement	Total Return
1960	1,500	33,200
1962	30,000	33,500
1963	12,000	10,000
1964	20,000	33,900
1965	10,000	13,000
1966	31,000	18,000
1969	3,000	67,400
1970	2,000	3,200
1971	51,000	16,100
1973	8,200	30,000
1974	200	1,500
1975	30,000	22,000
1976	1,500	1,200
1977	22,000	41,400
1978	1,100	7,500
1979	27,000	46,000
1980	7,500	35,700
1981	31,900	6,400
1982	15,500	27,300
1983	6,400	18,400
1984	18,800	208,100
1985	18,400	139,300
1986	137,000	84,900
1987	69,900	276,800
1988	35,000	37,600
1989	223,000	17,200
1990	3,380	

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